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Coalition Transformation: An Evolution of People, Processes, and Technology to Enhance Interoperability.

Rapid Knowledge Formation in an Information Rich Environment

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Symposium Topics Addressed:

C2 Decisionmaking and Cognitive Analysis

Network Centric Applications

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Abstract

This paper addresses the impact that increased availability of information has on decision making as an integral element of the command and control process and proposes a possible solution in the form of an Intelligent Assistant for Command and Control (IAC2). This IAC2 enhances current knowledge management technologies by emphasizing a dynamically responsive structure for information retrieval correlated to event recognition. The IAC2 employs technologies that are being investigated in connection with automated control of operations but limits their use to the search for information relevant to command decisions.

1 Introduction

The transformation of data into knowledge to promote understanding and decision making is a central focus for military command and control. This transformation continuum (Figure 1) lies at the heart of efforts to improve the accuracy and speed of military decision-making. The transformation engine is fed by facts, usually gained through observation. The first step in the process is to place these facts in the proper context to create information. The decision maker evaluates the information using experience and training to create knowledge. Often, due to time constraints and incomplete or inconsistent information, decisions are made at this point rather than after analysis of the situation leads to understanding.

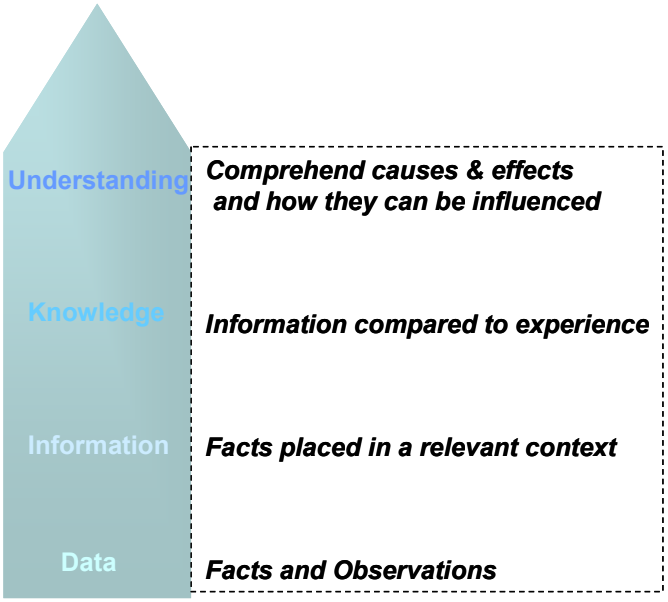

Figure 1: The Knowledge transformation continuum

This concept of the transformation of data into knowledge and eventually understanding was a key element in Colonel John Boyd's "Discourse on Winning and Losing".

"Boyd's theory of conflict advocates a form of maneuver warfare that is more psychological and temporal in its orientation than physical and spatial."[1] Boyd's theory calls for inducing paralysis in the enemy through the element of surprise and speed of maneuver. These same concepts were recently expressed in connection with the "Shock and Awe" concept used during OPERATION IRAQI FREEDOM.

In his "Discourse on Winning and Losing" Colonel Boyd introduced a process for assimilating data, transforming that data into knowledge, making knowledge-based decisions, and then implementing those decisions. This Observe, Orient, Decide, and Act (OODA) process came to be known as the OODA Loop.[2] This model also forms the basis for the analysis reflected in this report therefore a brief discussion of the OODA concept is in order.

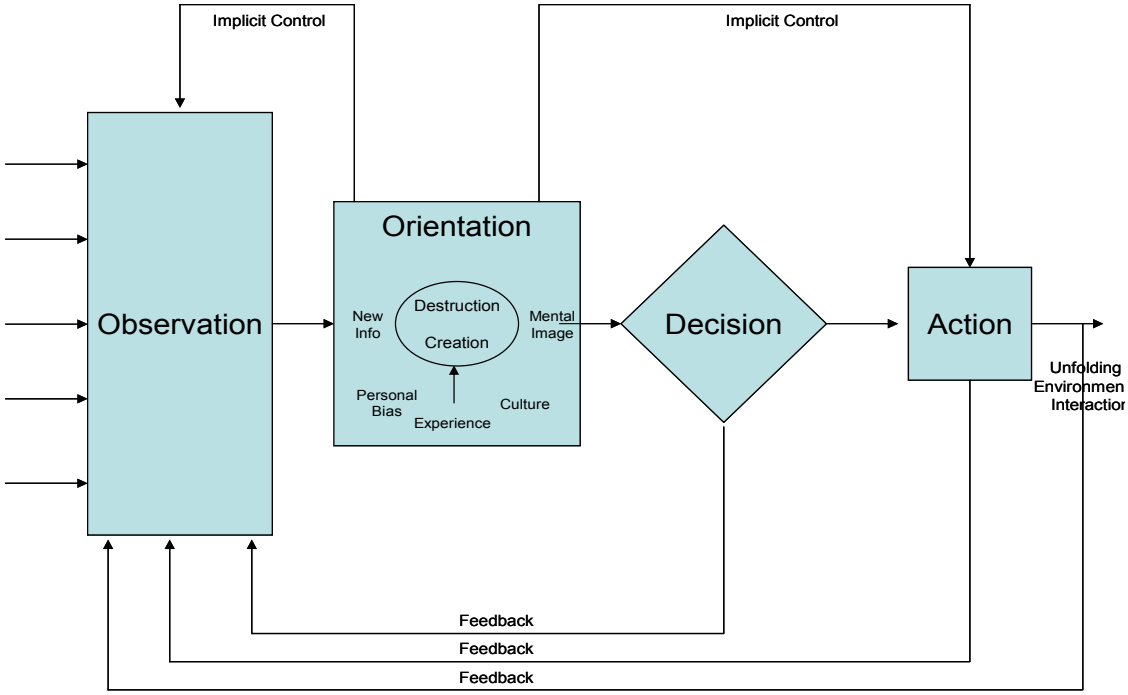

Figure 2: Boyd's OODA Loop

Facts and observations enter the process from the left in the form of data. This data is transformed into information as part of the observation process under the implicit control

[1] Fadok, David, "John Boyd and John Warden, Air Power's Quest for Strategic Paralysis" p.14

[2] Boyd, John "Discourse on Winning and Losing", 1987

of the "Orientation Process". This implicit control directs the observation process to seek out specific relevant facts in response to or in anticipation of one or more observations. This concept of controlling the observation process to accelerate knowledge formation in the orientation process is the focus of this paper. Another important element of the OODA Loop is Boyd's inclusion of knowledge, culture and genetics (renamed by this author as personal bias) as integral parts of the orientation process. Boyd also characterized the orientation process as one of creation and destruction. New knowledge is created while old concepts are often destroyed. Knowledge and understanding created through the orientation process leads to a command decision and subsequently to action. The OODA Loop represents a continuous process with no reference to re-planning. Decisions, once made, become facts to be observed, processed, and considered in subsequent decisions. The process moves continuously forward.

As stated previously, this paper focuses on the interactions between the Observation and Orientation processes of Boyd's OODA Loop. It proposes a method and related technologies that could be applied to meet the increasing needs for speed, accuracy, and relevant content for military decision makers.

2 The Problem

Up until the later decades of the 20th Century, the problem facing military decision makers was gathering enough facts in the proper time constraints to allow decisions that could dictate the orientation and tempo of operations. Observations were limited to a "line of sight" that extended just beyond the most forward placed forces. Additionally the utility of these observations were limited because information could not be easily shared with command elements located to the rear. At the same time, observations made by reconnaissance forces were available at higher command levels and were not quickly made available to operational commanders.

The technology development focus was to provide commanders with the ability to gather information from both lower echelon forces and from higher theater and national levels of command. As the graph at figure three shows, we have solved the problem of data availability shortfalls. Through World War Two, information flowed at a rate comparable to normal conversation rates. During Vietnam, we increased the rate to approximately

100 words per minute or a fast reading speed. During the first Gulf War, the ability to deliver content surged dramatically. Networked computers allowed us to transmit the equivalent of a 275 page book every minute. Today the ability to share data far exceeds the ability to read, understand, or comprehend with the equivalent of the entire Library of Congress transmitted every minute.[3]

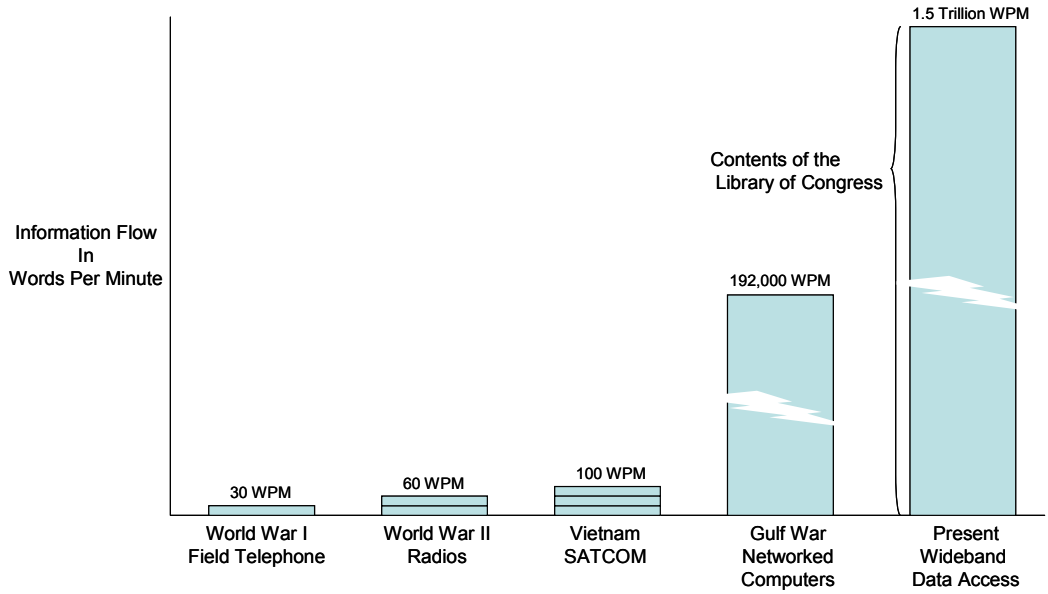

Figure 3: Growth in the ability to transmit information

Military decision makers today have an unprecedented ability to "see the battlefield" however; there is a greater need for commanders and staffs to understand the significance of the events they see. Modern information technology gives the military decision maker access to a tremendous amount of information extending his/her view of the battlespace. Recent operations in Iraq demonstrated our ability to rapidly react to opportunities within minutes of identification. These successes are astounding but the question must be asked; are they the exception or the rule.

Navy Doctrine Publication 6, Naval Command and Control makes the following observation regarding the transformation of information into knowledge.

[3] Rogers, Marc, "Joint Battle Management Command and Control"

> "Knowledge is a function of information so, as the quality on information increases, the effectiveness of the decision should also increase.
>
> At some point in the process, however, when basic knowledge has been gained and the quest for information focuses more on filling in details, we reach a point of diminishing returns... Beyond this point, additional information may have the opposite effect - it may only serve to cloud the situation, impede understanding, and cause the commander to take more time to reach the same decision he could have reached with less information. Therefore, it is not the quantity of information that matters; it is the right information made available to the commander at the right time."[4]

2.1 The Need for Information Management

The problem facing commanders today is that, while we can react quickly once an opportunity is identified; identification and correlation of relevant events[5] in the massive flow of information delivered to the commander is often difficult. Sifting through the mass of information today is a manpower intensive process aided by relatively primitive tools. Systems to filter based on key words, or originating organization can provide limited support but current automated tools lack the flexibility to adapt as the information needs of the decision maker change.

A review of the OODA Loop model can confirm the validity of the statement from the Naval Doctrine Publication. As the amount and sources of data feeding the Observation process increase, there is a greater need to filter the information before relevant information is allowed to pass to the Orientation Process. If not accurately employed, this filtering can cause a series of loops where the decision maker must identify additional information needs by sending updated guidance to the observation function. The observation function will enact the revised guidance and new information will flow. The problem is that this process can be repeated numerous times before the right information flows to support the decision analysis. The problem is that this looping early

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[4] "Decision Making Theory, Naval Doctrine Publication 6 Command and Control"

[5] Detection and correlation maps to the Observe and Orient of the OODA Loop.

in the process delays the decision and impacts the commander's ability to create confusion in the enemy.

As the ability to deliver information increases, there is an increased demand for capabilities to support filtering and transformation of information. We are seeing the introduction of a number of tools supporting "value added" processing of information. New technologies for information fusion, filtering, and dissemination will help the decision maker but do not address a key issue in the decision process. One example of the application of technology to impact of information overload is the Air Force Research Laboratory's Joint Battlespace Infosphere (JBI) Program. As a fact sheet for the JBI program states, "Commanders, warfighters and other combatants need an information management and exchange capability that supports tailorable, dynamic, and timely access to all required information to enable real-time planning, control, and execution of the aerospace mission."[6]

The Joint Battlespace Infosphere (JBI) provides an enterprise wide information management system that promises to support military decision makers at all levels of command. The JBI is a JINI-Based system that facilitates fine-grained specification of information needs. As currently envisioned, the JBI offers a publish and subscribe environment that supports all aspects of a military operation. Through "Force Templates" the JBI seeks to identify a basic set of information needs for units as they arrive in the area of operations. Fuselets provide a means to perform near the source filtering and transformation of data into information design to support specific command and control needs. The JBI offers a dramatic step forward for commanders operating in an information-rich environment. Is it enough?

While the JBI currently offers one of the "best of breed" information management capabilities it may fall short in some significant areas.

First, while the JBI provides a dynamic subscription capability, the subscriptions themselves are not agile enough to respond to the shifting needs of the military decision maker without overloading the information delivery channels. The military decision

[6] AFRL Information Directorate, Joint Battlespace Infosphere, p-1

maker's information needs change based on his/her own actions, the actions of related units, and enemy responses. The insignificant fact may become critically important under the right circumstances but only serve to clutter the information space at all other times. There is clearly a need for a system that can anticipate the needs of the decision maker based on detected events, locate the critical elements of information, and deliver that information in the proper context and presentation format only when needed to facilitate rapid understanding and decisions.

Second, information sources are often configured to begin the transformation process by converting data into information relevant to a group of decision makers. This act limits the flexibility of the information source to satisfy the potential spectrum of information needs by making the source "too smart". Transformation within the source, the argument goes, is needed to limit the amount of data flowing across limited bandwidth. What is needed, is a general purpose information source that can support a variety of information needs without broadcasting a continuous stream of data elements that has limited utility under most circumstances. Perhaps the intelligence could be put into the subscription such that a single, simple information source could support a number of divergent information needs through filtering and transformation in the subscription itself. This concept is based on a new definition of subscription where the subscription embodies the characteristics of intelligent software agents that travel from the consumer to the source of information where they filter and transform data into meaningful information and only transmit the information back to the consumer when a specified set of conditions are met.

2.2 Information Management for Network Centric Warfare

The capabilities envisioned by Network Centric Warfare will be achieved through an evolutionary process. Today we are seeing an expansion in the concept of military decision maker to encompass personnel at all levels of command down to the individual soldier. We are also seeing the introduction of concepts to distribute decision making across the organization. In part, this distributed decision making concept reflects the introduction of information technologies that are capable of rapidly delivering information to military decision makers at all levels of command. It also responds to a growing recognition that there is too much information flowing to be concentrated at a few command nodes.

The JBI supports a JINI-Based publish and subscribe system to support the flow of command relevant information across a geographically dispersed organization. The JBI allows commanders to quickly identify relevant information sources (publishers) based on content and then subscribe to specific elements of information from these sources. JINI supports many essential capabilities necessary for this type of a system including dynamic discovery of relevant sources and house keeping functions that allow nodes to enter and leave the infosphere without disrupting the overall functioning of the system. Of greater importance from a JBI perspective, JINI supports a much finer granularity for subscriptions that is possible from other commercially available technologies.

The publish and subscribe construct also supports a loosely or decoupled environment for publishers and subscribers. This means that one could construct a publisher with little or no foreknowledge of how the information made available would be used. This loosely or decoupled environment essentially breaks the stovepipe of traditional command and control applications and improves the interoperability and extensibility of the overall command and control system.

There are some limitations in publish and subscribe frameworks when applied to the Network Centric Warfare concepts of operational agility and self synchronization. First, operational agility and self-synchronization will depend on the decision maker's ability to quickly and accurately understand the broad significance of reported events by placing them into the correct operational context as the first stage of knowledge formation. What is this "correct" operational context? The answer in most cases is "It depends". The dynamic nature of operational context poses significant difficulties for any automated system based on a fully- or partially static set of rules. This drives the need for relatively large staffs to facilitate human centered analysis. Once again, a review of Boyd's OODA Loop model identifies the central role that knowledge, experience, culture and personal biases have on the transformation and decision process.

These characteristics are unique to the individual and although there is a certain degree of common education and training, two individuals, looking at the same information display, can reach vastly different assessments resulting in divergent and non-synchronized decisions. Also, while the publish and subscribe capabilities of systems such as the JBI are dynamic in that they can adjust and adapt to the loss of a publisher

node or, given sufficient time, modify subscriptions, they will lag behind the commander's information needs because the are in the reactive not proactive mode.

3 An Intelligent Assistant for Command and Control

Thus far, this paper addressed the need for commanders and staffs at all levels of command to rapidly detect significant events in the sea of information flooding command centers. The paper also discusses promising technologies that can provide an intelligent assistant for the commander that can identify potentially relevant events, place the events into the proper context through automated queries, then present the information to the decision maker in a manner that promotes rapid knowledge formation.

The paper highlighted the evolution of information dissemination methodologies from the push system, through the smart push and smart pull systems. It discusses a major weakness in these concepts that impacts the development of automated tools for information monitoring and event detection. This weakness is flexibility. The information needs of any single decision maker are dynamic, shifting over time in response to circumstances. What is significant at one moment may be of limited importance later. The dynamic nature of command information requirements impacts the utility of any system based strictly on rules such as smart push, smart pull, and some publish and subscribe methodologies.

This paper now proposes an intelligent assistant that interacts with a set of information services and event monitors (subscriptions) supporting the dynamic information needs of the decision maker. The proposed Intelligent Agent for C2 (IAC2) (Figure 4) employs a number of technologies currently being investigated by the Defense Advanced Research Projects Agency (DARPA) and other research laboratories around the world. These technologies include JINI – based and other service architectures, intelligent agents, knowledge management systems employing artificial intelligence components. These technologies will employ ontologies similar to those developed to support the semantic web, active templates to provide a manageable set of search criteria and, source filtering and transformation to limit the number of reported events to those that are significant in the current situational context.

3.1 Intelligent Assistant Architecture

The IAC2 has three primary components; the IAC2 Information Consumer, the IAC2 Information Provider, and the IAC2 Subscription Module. These modules are described below.

3.1.1 IAC2 Information Publisher:

The IAC2 Information Publisher is a JINI Service. The IAC2 Publisher consists of a central Publishing Process Module and four distinct interfaces.

The Publisher Processing Module contains instructions that specify the information reported, frequency of reports, and the metadata references. This module also contains the logic for several important housekeeping functions. These include subscription management and monitoring functions which are critical for effective operation of the

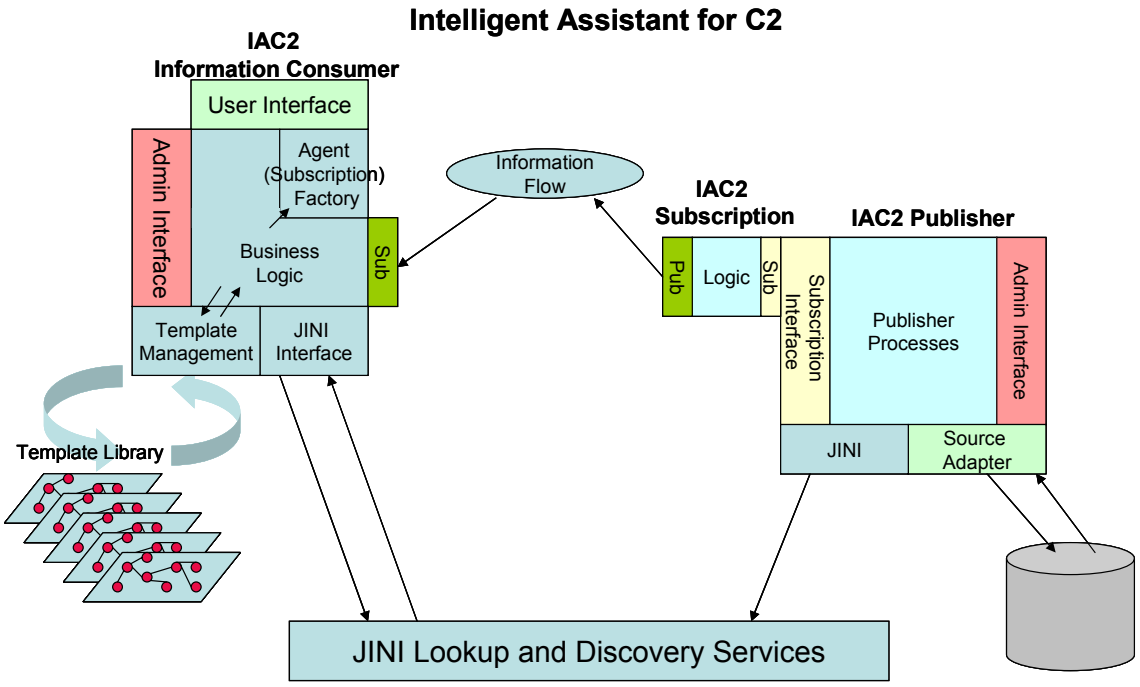

Figure 4: IAC2 Architecture

IAC2 system. House keeping functions manage the registration and validation (possible using certificates) of all subscriptions. The housekeeping functions monitor the operation of the subscription and can terminate any subscription that does not conform to normal behavior rules. For example, the IAC2 Publisher housekeeping function would monitor subscription processor usage and can terminate the subscription if the subscription

exceeds a pre-defined limit. The house keeping function maintains leases with all active subscriptions and monitors lease renewals and terminations. The housekeeping function can delete subscriptions when the lease has expired.

The IAC2 Publisher is owned and managed by the owner of the resource being monitored. This management is implemented through the Administrative Interface.[7] The IAC2 Publisher JINI is a service-based framework designed to operate in less than optimal conditions. JINI does not assume 100% availability of network services therefore it provides dynamic discovery of available services and, to a limited degree, a self healing capability. JINI employs a "lease" concept where individual services register with JINI lookup and are granted a "lease". The term of this lease is owner configurable. Each service must periodically renew its lease. If a service loses contact with the JINI lookup and its lease expires, it is dropped from the list of available services until it reestablishes contact at which time it is granted a new lease. The IAC2 information providers have a JINI interface that connects to JINI Lookup Services to establish and maintain leases. The JINI Interface also provides update information (Metadata) when the configuration is modified by the resource owner. In the form of monitors are configured as JINI services.

3.1.2 IAC2 Information Consumer

The IAC2 Information Consumer is the most complex module of the IAC2 System. It also has an Administrative Interface used by the supported decision maker to configure the module. The User Interface provides alerts to the decision maker when specific parameters are met. It can also provide information regarding the preferred display for user defined information that can be used to instantiate specific visualization tools. The IAC2 Information Consumer also acts as a JINI service through a JINI Interface. It establishes and maintains a connection with the JINI Look-up services as well as publishing a proxy for other IAC2 Information Consumers to access the current information requirements profile or to receive alerts when this profile changes. This aids in self-synchronization by providing a mechanism for a decision maker to identify the

[7] This concept of ownership was used by BBN in developing the BBN Distributed Monitoring Architecture (BDMA). This paper borrows from the concepts developed by the BDMA team.

current or shifting information needs of adjacent or related decision makers. It helps answer the question, "What is the XXX Unit doing about this?"

The heart of the IAC2 Information consumer is the business Logic module. This module employs rules based and other artificial intelligence mechanisms to monitor the current situation and then to tailor the information requirements parameters in accordance with predefined information need templates. These templates are based on research conducted by DARPA and AFRL as part of the Active Templates project. The use of templates attempts to reduce the complexity of search parameters from an extensive set of individual, interconnected rules to a more finite set of template rules.

Search templates are initially defined using doctrine and standard operating procedures. Once defined, the templates are made available to the individual decision makers where they are tailored for the needs of the individual. The Business Logic Module accomplishes this through a Template Manager that organizes the individual templates into libraries, retrieves specific templates in response to decision maker pre-defined search requirements, and updates the personalized templates based on decision maker defined adjustments to the search parameters.

For example, a military decision maker has defined a set of personalized templates by modifying the standard templates provided with the IAC2 System. One of these templates supports the information requirements for a detected shortage of a specific weapon type. The IAC2, through an Information Publisher and attached subscription detect a defined shortage at one base. The Business Logic module requests the applicable template(s) from the Template Manager and directs the subscription factory to constructs a set of subscriptions to support the search requirements. When the information resulting from the search is returned the decision maker identifies an additional search requirement. This information is returned which triggers a second modification. When the decision maker dismisses the presentation, the Business Logic Module asks if the modifications should be added to the template. If the decision maker answers yes, the template is adjusted and stored for future use.

This process could be modified by adding a self learning capability to the IAC2. This self learning could use pattern density calculations to identify user defined search requests and automatically add these to the template once a specified density was

reached. The problem with this approach is that is does not account for the discarding of unused search parameters since it is not possible, without user interaction, to define the unneeded information elements.

The final component of the IAC2 Information Consumed module is the subscription factory. This component uses the requirements of the search template and the results from a JINI request for matching services to construct and deploy a set of subscriptions in the form of agents defined as JINI services.

3.1.3 IAC2 Subscriptions

The final component of the IAC2 System are the subscriptions that are dynamically created, deployed, and destroyed in response to shifting information needs. As stated previously, IAC2 Subscriptions are software agents defined as JINI Services. They are created by the Subscription Factory component of the Information Consumer and are owned by the decision maker served by the Information Consumer module. The subscriptions are managed by the Information Providers through the housekeeping functions.

3.2 IAC2 Design Assumptions

The IAC2 framework is based on a decoupled environment where information providers (publishers) and consumers interact through subscriptions. The information providers and consumers do not have any detailed knowledge of each other outside of the fact that the providers are JINI services with a specific interface for subscriptions.

Information providers are constructed as JINI services. They register with JINI lookup and initiate and maintain leases. The fundamental difference is that the IAC2 information providers can only provide information to a self contained interface. This interface provides a "docking station" for subscriptions in the form of mobile code. To support the use of mobile code subscriptions, the information providers possess a set of management capabilities that are used to manage the subscription elements. The information providers maintain a lease structure that allows unused or unneeded subscriptions to be discarded in an orderly manner.

Consumers understand JINI services and how to obtain information through subscriptions. The consumers also have access to a command and control ontology that

supports semantic representation of command and control information. By using this ontology, the consumers are able to determine (during the discovery process) if a specific information provider can support the information needs and the actions needed to transform the data published into relevant information.

Subscriptions are modules that connect to and are managed by the information provider services. These subscriptions are created by the information consumers to fulfill specific information needs. The subscription contains a set of instructions, based on business logic that transforms and filters the information provided by the publisher. This concept is explained in the example below.

3.3 IAC2 Example

For example, suppose that a commander is interested in a specific weapon configuration for 2000 lb bombs. At the same time, there are a set of publishers that monitor the database status of bombs and bomb components stored at seven operating bases in the AOR. These publishers provide status information on all bomb and bomb components at the base every thirty minutes.

An Intelligent Assistant associated with the decision maker creates and sends a subscription to each of these publishers. These subscriptions attach to the docking station on each of the publishers and define an information need for each relevant component. The publisher begins delivering this status to the subscription. The subscription further processes this data transforming it into information of use to its owner. In this case, the commander is concerned that the stocks of these particular "smart bombs" not drop below a three day supply without alerting him. The subscription uses the information provided by the publisher to identify the number of complete weapons available at the based each thirty minutes. Additionally, since the publisher reports components going out and the number of weapon components coming in to the stockpiles, the subscription is able to develop an approximate usage pattern for the base. The subscription maintains an average daily usage and the current number of weapons available. It does nothing with this information until the number of stocks falls below the three day average usage. It then issues an alert to the Intelligent Assistant.

Upon receiving the alert, the Intelligent Assistant retrieves a specific set of information retrieval requirements stored as a template. It then executes a series of subscriptions based on this template to determine the impact of the event. In the case of our example, the Intelligent Assistant issues a new subscription that queries each base for the specific number of weapon components on hand now. It also queries a publisher attached to a node of the Global Transportation Network to request the status of any weapon components (from the interest list) currently in transit. These subscriptions only have a limited duration and will be allowed to self-destruct once the immediate need for information is over. In the case of our example, the Intelligent Assistant determines that the shortage is limited to a single base and that replacement components were delayed enroute but are expected within the next twelve hours. The Intelligent Assistant may issue an alert to the decision maker and include the information related to the pending arrival of the delayed shipment or, if within acceptable parameters, may only issue a notification recommending that the arrival be monitored.

4 Conclusion

This paper sought to explore the information rich command and control environment, identify current capabilities and their potential limitations, and propose a new generation of knowledge management tools based on technologies currently being researched. It proposes combining these technologies to provide a system that supports and not replace human decision makers.

The use of agents as an integral part of a command and control structure is gaining acceptance. The Army's Future Combat Systems (FCS) development effort is providing an agent based system that encapsulates agents as services and services as agents to provide a dynamic, flexible decision tool.

The concept of using templates to represent search parameters facilitates training and portability for decision makers as they move between commands. A commander, having developed a personalized set of templates, could make a copy of these templates and install them on the system at the new command. Additionally, the templates could provide a valuable tool for successors by providing some insight into the thought process of previous commanders.

Bibliography

Albers, David S., **Information Age Transformation, Getting to a 21st Century Military**, CCRP, Washington DC, 2002

Albers, David, S., Garstka, John, J., and Stein, Fredrick, P., **Network Centric Warfare, Developing and Leveraging Information Superiority**, CCRP, Washington DC, 1999

Mulvehill, Alice, Callaghan, Michael, Hyde, Clinton, "*Using Templates to Support Crisis Action Mission Planning*", 2001

Berry, P.E, Hall, D.L., Fogg D. A. B., Fok, V, "*Modeling Information and Decision Making under Uncertainty for Integrated Surveillance Operations*", Salisbury, Australia

"*The Joint Battlespace Infosphere*", Air Force Research Laboratory, Information Directorate Fact Sheet, Rome NY, 2000

Decision Making Theory – Naval Doctrine Publication 6, Naval Command and Control, Washington DC, 1995

Combs, Vaughn and Linderman, Mark, "*A Jini-Based Publish and Subscribe Capability*, Air Force Research Laboratory, Information Directorate, Rome NY, 2001

Blyth, J, Kim, J, Ramachandran, S, Gil, Y, *An Integrated Environment for Knowledge Acquisition*, ISI, Presented to International Conference on Intelligent User Interfaces, 2001

Fadok, David S., **John Boyd and John Warden, Air Power's Quest for Strategic Paralysis**, Air University Press, Maxwell AFB AL, 1995

Rogers, Marc, "*Joint battle Management Command and Control*" NDIA-SPAWAR Industry Conference, 2003

Rapid Knowledge Formation in an Information Rich Environment

Prepared for the 2004 CCRTS

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Presentation Overview

- Knowledge Formation and C2
- The Problem
  - Recognition and Association
  - Dynamic Adjustment
  - Information Delivery
- Intelligent Assistant for C2
  - Concept
  - Architecture

C2 Knowledge Formation

- Battlefield agility begins with:
  - Detection and recognition of key events reflected in data
  - Assembling these individual data elements into relevant information
  - Forming knowledge by comparing information to past experience
  - Seizing the initiative through insight and understanding of causes and relationships

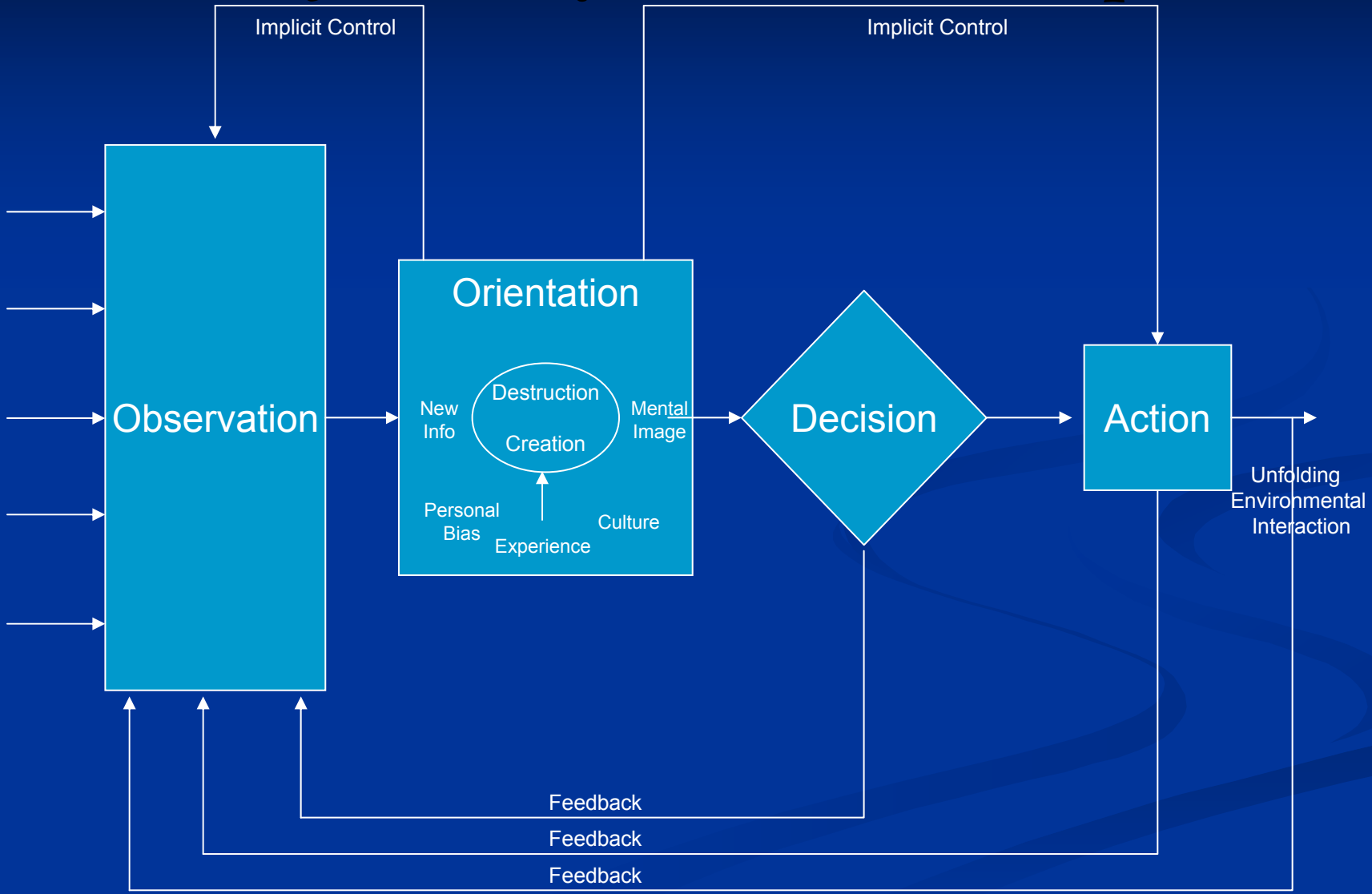
Comprehend causes & effects and how they can be influenced

Information compared to experience

Facts placed in a relevant context

Facts and Observations

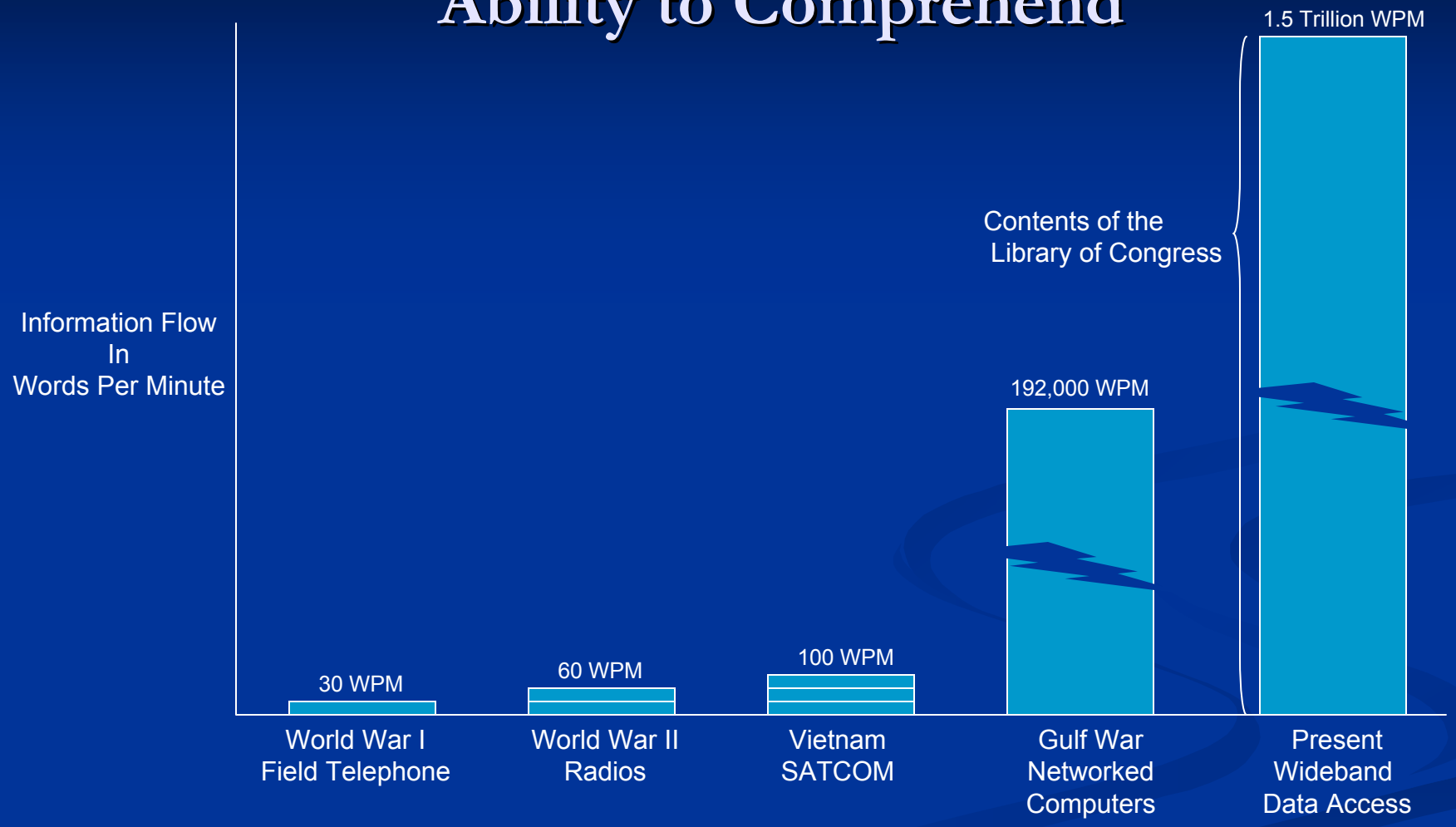
John Boyd's OODA Loop



Technology Impacts on Command Agility

- Volume and speed of data delivery
  - Technology investments in information dissemination paying off
    - Deliver increased amounts of data to the commander
    - Volume of information delivery capability outpaces ability to assimilate the information
- Automated Fusion capability delivers more information than data
- Technology has facilitated the move from "push" and "pull" models to "publish and subscribe"
  - Decouples sources and consumers
  - Employs early filtering to remove information clutter

Information Delivery Capability Outpaces our Ability to Comprehend



Addressing Information Overload

- Technologies supporting discovery and filtering emerging
  - Agents and agent societies can help ensure that commanders receive relevant information
    - Often require constant management. Difficult to tailor to individuals
  - Source and near source transformation technologies begin the fusion process early
    - Fusion technologies often placed at information source
    - Limits adaptability if source data hidden
- Technology treats information as a commodity
  - Fails to support the dynamically changing needs of the decision maker

Dynamic Information Needs

Needs are Structured By:

- Own Situation
- Planned Actions
- Nearby Friendly Unit Situation
- Nearby Friendly Planned Action
- Enemy Situation
- Perceived Enemy Intentions

Needs are Satisfied By:

- Directed Queries
- Trusted Information Sources
- Known Information Sources
- Undirected Queries
- Available Information Sources

Needs are Triggered By:

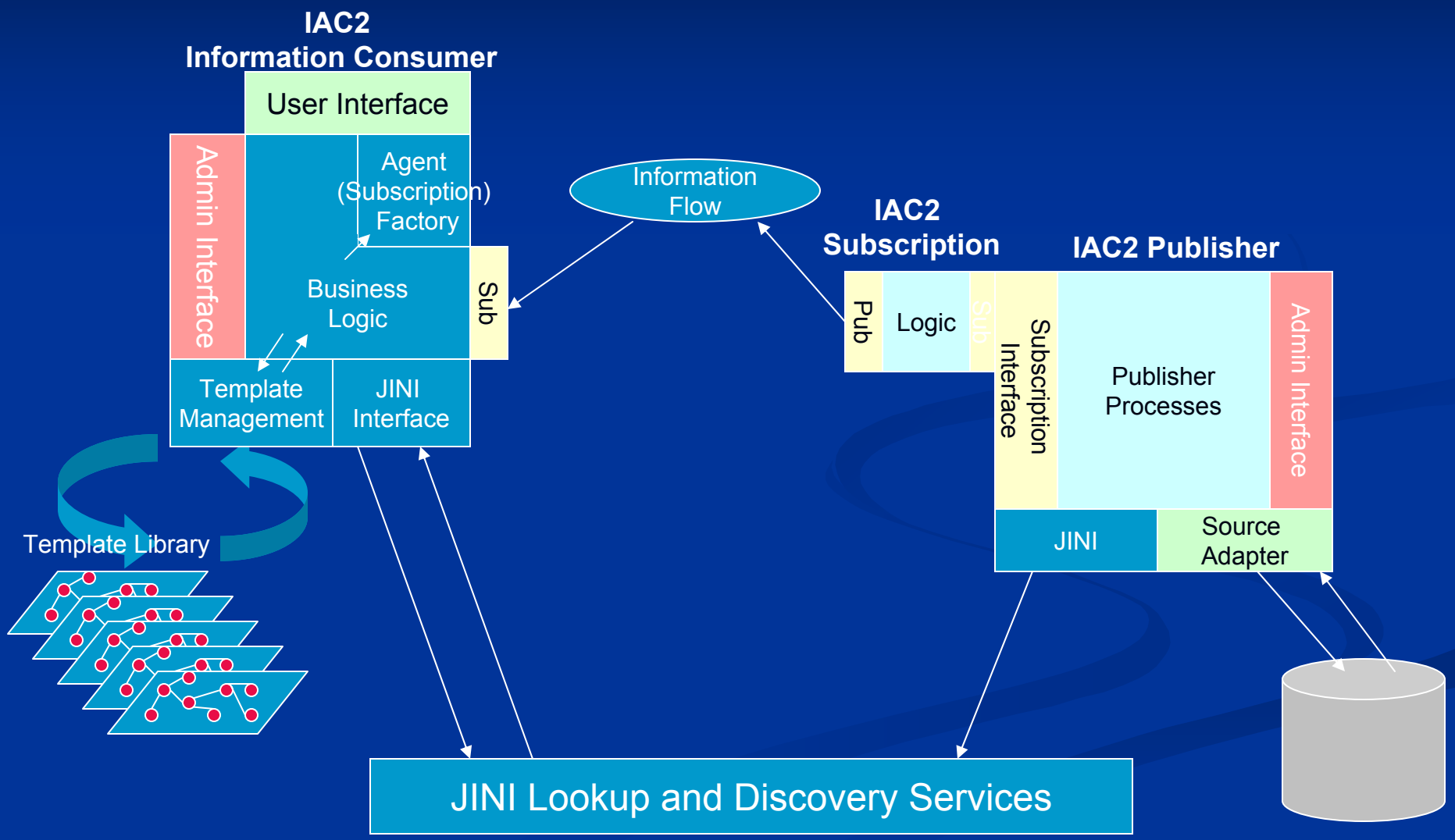
Conceptual Framework for the Intelligent Assistant for C2

- Information needs can change dynamically:
  - Often the result of a combination of events
  - Each event can trigger additional information needs
- Subscriptions to information sources are transitory
  - Established to fulfill a specific need then abolished
- Each decision maker has specific information needs
  - Differences in:
    - Experience
    - Methods for knowledge formation

Basic Technologies for the Intelligent Assistant for C2

- COTS foundation
  - Employ standards based components (JINI)
- Leverages previous DoD sponsored research
  - Including Active Templates, JBI, ACEM
- Monitors and Consumers are decoupled
  - Monitors
    - Focus on providing information from sources
    - Simple information representation
    - Can manage consumer subscriptions
  - Consumers
    - Focus on information needs
    - Can discover and subscribe to sources
    - Include and Intelligent Assistant
      - Template based approach for supporting information needs
      - Dynamically create subscriptions

Intelligent Assistant for C2 Architecture



Conclusion

- Technology focus on delivering decision quality information in a complex, rapid paced environment
- Consumer managed near source filtering and transformation
- Adaptable knowledge based assistants to manage information delivery